

**Inertial Brake Actuator for Towed Vehicle**

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1                   INERTIAL BRAKE ACTUATOR FOR TOWED VEHICLE

2   REFERENCE TO PRIOR APPLICATION

3       [001]    This application claims the benefit of the previously filed  
4   provisional application number 60/407,500.

5   FIELD OF THE INVENTION

6       [002]    The present invention relates to braking systems for towed  
7   vehicles. In particular, this invention relates to a device for actuating  
8   the brakes of a vehicle being towed in such a manner as to be responsive to  
9   the deceleration of the towing vehicle.

10   BACKGROUND OF THE INVENTION

11      [003]    Ordinarily, the combination of a first vehicle such as a motor  
12   home and a second vehicle such as an automobile or a light truck, where the  
13   first vehicle is towing the second vehicle, is stable on the road. However,  
14   there are circumstances when the combination can become unstable because of  
15   driving conditions normally encountered at highway speeds. For example, when  
16   the combination is overtaken by a large vehicle, it may be subject to wind  
17   turbulence effects of varying severity, depending on the size and speed of  
18   the overtaking vehicle. This can cause rocking, snaking or jackknifing of the  
19   combination. Such instabilities are known to cause accidents, particularly  
20   at highway speeds.

21      [004]    As another example, instabilities can arise as a result of the  
22   towing vehicle having to brake suddenly. In the case of sudden braking, the  
23   brakes of the towing vehicle are usually not designed to stop with the  
24   additional weight carried by the towed vehicle, resulting in a longer  
25   stopping distance than would otherwise obtain at normal towing vehicle

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1 weight. Moreover, the towed vehicle may decelerate more slowly than the  
2 towing vehicle, resulting in snaking, jackknifing or other instabilities.

3 [005] As still another example, instabilities can arise as the result  
4 of the towing vehicle swerving to avoid road obstacles such as animals or  
5 tire debris. Ordinarily, if given sufficient time, the driver can avoid the  
6 obstacle by steering smoothly around it. However, if the obstacle is  
7 encountered suddenly, such as in circumstances where an animal darts out in  
8 front of the towing vehicle or the animate or inanimate obstacle is  
9 encountered on a curve or on a hill, the driver may attempt to avoid the  
10 obstacle by swerving suddenly and the combination may become unstable because  
11 the forward momentum of the towed vehicle may briefly cause the rear of the  
12 towing vehicle to skid in a sideways direction relative to the forward  
13 direction of the towing vehicle. Such instabilities manifest themselves as  
14 jackknifing or snaking and in severe cases, may result in the combination  
15 rolling over.

16 [006] One method of returning an unstable combination to stability in  
17 situ is to accelerate the towing vehicle, causing a pull between the towing  
18 vehicle and the towed vehicle, which acts to dampen the instability.

19 However, under certain circumstances, for example, if the combination is  
20 traveling down hill or if the speed of the combination is high at the onset  
21 of the instability or if jackknifing has caused the towing vehicle to swerve  
22 away from its intended direction, acceleration of the towing vehicle will not  
23 produce the required pull between the towing vehicle and the towed vehicle.  
24 Under such circumstances, acceleration of the towing vehicle can merely  
25 aggravate the situation.

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1        [007]    In order to enable the combination of vehicles to slow safely or  
2    to decelerate the forward motion of the towed vehicle in a coordinated  
3    fashion with that of the towing vehicle, such as when the combination must  
4    swerve to avoid a road obstacle, several methods of applying the brakes of  
5    the towed vehicle have been developed. For example, in US Patent 2,177,469,  
6    White discloses an auxiliary hydraulic actuator for applying the brake pedal  
7    of the towed vehicle when the brakes of the towing vehicle are applied. The  
8    system does not require modification of the existing brake system of the  
9    towed vehicle. However, the vacuum required to operate the hydraulic pedal  
10   pusher is supplied by the vacuum system of the towing vehicle through a hose  
11   connecting the two vehicles. This approach requires costly connecting hoses  
12   and fittings. Moreover, an encounter with road debris could result in  
13   breakage or disconnection of the vacuum hose, resulting in a loss of vacuum  
14   in the engine of the towing vehicle and a shutdown of the power assist  
15   portion of the braking system without warning.

16        [008]    Another means of solving this problem was disclosed by Latham in  
17   U.S. Patent number 5,954,164. This patent teaches an inertial actuator for a  
18   towed vehicle braking system in which a weight, mounted on a pendulum,  
19   actuates the brake pedal of the towed vehicle. To augment the power assist  
20   function of the towed vehicle, an auxiliary vacuum system is provided. The  
21   installation of the inertial actuator module requires considerable time and  
22   effort. For example, the module is bolted to the floor of the towed vehicle,  
23   which may require drilling through the floor. In addition, a special fixture  
24   is required on the arm supporting the brake pedal for engagement with the  
25   pedal engaging surface. Installation of this fixture also requires holes to  
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1 be drilled in the pedal arm. Considerable time must be spent dismounting the  
2 actuator module once the combination arrives at its destination.

3 SUMMARY OF THE INVENTION

4 [0009] It should be understood that the term "means" is used to invoke  
5 "means plus function" language.

6 [0010] The present invention, according to its first broad aspect  
7 provides an inertial brake actuator for a towed vehicle having a floor and a  
8 braking system actuated by a brake pedal comprising: (a) a base, comprising a  
9 top side and a bottom side; (b) a weight comprising a means for contacting  
10 the brake pedal, a top and a bottom, slidably mounted to the base along a  
11 line of travel between a forward position and a rearward position, wherein  
12 the means for contacting the brake pedal are configured to actuate the brake  
13 pedal responsive to the deceleration of the towed vehicle and wherein the  
14 weight has sufficient mass to apply a braking force to the brake pedal during  
15 deceleration of the towed vehicle; (c) sliding means between the base and the  
16 weight wherein the sliding means enforce said line of travel between said  
17 forward position and said rearward position.

18 [0011] Various modifications can be made to the first broad aspect of  
19 this invention. For example, one can employ a means of attaching the brake  
20 pedal to the weight. As another example, the sliding means can be configured  
21 between the top of the base and the bottom of the weight. As still another  
22 example, the weight can comprise a plurality of separable weight segments so  
23 as to adjust the mass of the weight to apply a proper braking force. It  
24 should be noted that the individual weight segments need not be identical.  
25 As still another example, the base can further comprise means for  
26 constraining the motion of the base relative to the motion of the towed

1 vehicle so that the brake actuator does not move out of position in response  
2 to tilt, centripetal acceleration or jarring of the towed vehicle. As still  
3 another example, there is provided a means for moderating the motion of the  
4 weight along its line of travel. As another example, there is provided a  
5 weight portion of the brake actuator that has sufficient mass to slow the  
6 towed vehicle by at least 10 percent. As yet another example, there is  
7 provided a weight portion of the brake actuator that has sufficient mass to  
8 slow the towed vehicle by at least 50 percent.

9 [0012] According to its second broad aspect, this invention provides an  
10 inertial brake actuator for a towed vehicle having a floor and a vacuum-based  
11 power assisted braking system actuated by a brake pedal comprising (a) a base  
12 comprising a top side and a bottom side; (b) a weight comprising a means for  
13 contacting the brake pedal, a top and a bottom, slidably mounted to the base  
14 along a line of travel between a forward position and a rearward position,  
15 wherein the means for contacting the brake pedal are configured to actuate  
16 the brake pedal responsive to the deceleration of the towed vehicle and  
17 wherein the weight has sufficient mass to apply a braking force to the brake  
18 pedal during deceleration of the towed vehicle; (c) sliding means between the  
19 base and the weight wherein the sliding means enforce said line of travel  
20 between said forward position and said rearward position; (d) an auxiliary  
21 vacuum source connectable to the towed vehicle braking system to augment the  
22 actuation of the towed vehicle braking system.

23 [0013] The various modifications to the brake actuator module are the  
24 same as those provided for in the first broad aspect supra and are  
25 incorporated herein by reference. A further modification of the second  
26 broad aspect of this invention is that the auxiliary vacuum source comprises

1 a vacuum pump. Yet another modification to the second broad aspect of this  
2 invention is that the vacuum pump is operated electrically. A further  
3 modification of the second broad aspect of this invention is that the vacuum  
4 pump operation is controlled by a normally-on vacuum switch.

5 [0014] One advantage of the present invention is that there is no  
6 connection between the towing vehicle and the braking system of the towed  
7 vehicle.

8 [0015] Another advantage of the present invention is that very little  
9 time is required to move the brake actuator module from its operating  
10 position to its stored position so as to render the towed vehicle ready to  
11 drive.

12 [0016] Still another advantage of the present invention is that the  
13 brake pedal actuator module is installed in such a way that the inertial  
14 force applied to the brake pedal of the towed vehicle is applied in nearly  
15 collinear fashion with the motion of the brake pedal. This means that setup  
16 of the actuator system and the means of moderating the motion of the weight  
17 can be done very simply. For example, when driving an automobile equipped  
18 with power brakes on a dry, level concrete surface, the tires will lose  
19 traction and begin to skid at about 0.7 G. This occurs with a force applied  
20 to the brake pedal of about 35 lb. On wet pavement skidding will occur at a  
21 deceleration of 0.6 G or less when the force applied to the brake pedal is  
22 approximately 30 lb. The selection of the mass of the weight and the  
23 strength of the spring used to prevent the weight from being applied when  
24 there is no deceleration can thus be done very simply.

25 DESCRIPTION OF THE DRAWINGS

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1 These and other advantages of the present invention will be more fully and  
2 completely understood in accordance with the following description.

3 [0017] Figure 1 is a side view of the driver's compartment of the towed  
4 vehicle when the brake actuator module is in operation.

5 [0018] Figure 2 is a side view of the driver's compartment of the towed  
6 vehicle when the brake actuator module is in operation. In addition, there  
7 is provided a separate module for vehicles with power-assisted brakes. This  
8 module is shown diagrammatically by the dashed rectangle on the opposite side  
9 of the towed vehicle's firewall.

10 DETAILED DESCRIPTION OF THE DRAWINGS

11 [0019] Shown in Figure 1 is the driver's compartment of the towed  
12 vehicle. The weight at 1 is attached to a slidable ball bearing mount at 2  
13 which, in turn, is attached to a base at 3. The module is aligned with the  
14 brake pedal at 4, which is mounted to the fire wall at 5. A spring or bungee  
15 cord 6 is used to hold the weight back from the brake pedal so that it will  
16 only slide forward during a forward deceleration of sufficient magnitude. In  
17 this embodiment, the spring or bungee cord is attached to the weight at its  
18 handle 8 and to an existing support bracket 9 underneath the car seat 10. In  
19 order to prevent sideways motion, the weight 1 is loosely attached to the  
20 brake pedal by a pair of hooks 7 which are mounted to the top of the weight  
21 by hinges. As can be seen, the module can be removed for driving after  
22 releasing the spring or bungee cord 6 and rocking the hooks 7 back away from  
23 the brake pedal so that they rest on the weight.

24 [0020] Shown in Figure 2 is the driver's compartment of the towed  
25 vehicle and a diagram of the engine compartment on the other side of the  
26 firewall. The weight at 11 is attached to a slidable ball bearing mount at

1    12 which, in turn, is attached to a base at 13. The module is aligned with  
2    the brake pedal at 14 which is mounted to the fire wall at 15. A spring or  
3    bungee cord 16 is used to hold the weight back from the brake pedal so that  
4    it will only slide forward during a forward deceleration of sufficient  
5    magnitude. In this embodiment, the spring or bungee cord is attached to the  
6    weight at its handle 18 and to an existing support bracket 19 underneath the  
7    car seat 20. In order to prevent sideways motion, the weight 11 is loosely  
8    attached to the brake pedal by a pair of hooks 17 which are mounted to the  
9    top of the weight by hinges. As can be seen, the module can be removed  
10   easily for driving after releasing the spring or bungee cord 16 and rocking  
11   the hooks 17 back away from the brake pedal so that they rest on the weight.

12       [0021] Also in Figure 2 is an auxiliary source of vacuum, shown in the  
13   dashed box at 21 on the opposite side of the firewall 15. The electrical  
14   vacuum pump 22 is powered by a connection to the towed vehicle fuse box at  
15   23. A manual on-off switch 24 is used to limit the operation of the vacuum  
16   pump to those times when the vehicle is being towed. The operation of the  
17   vacuum pump is further limited by a vacuum actuated switch at 25,  
18   electrically connected in series with the manual on-off switch 24. A vacuum  
19   hose 26 runs from the vacuum pump at 22 to the vacuum switch at 25. A second  
20   vacuum hose at 27 runs to a check valve 28, which, in turn, is connected to  
21   the brake booster at 29. In normal operation, the vacuum is provided by the  
22   engine, which is connected via a vacuum hose 31 to a check valve 32, which,  
23   in turn, is connected to the brake booster at 29. Once the required vacuum  
24   is achieved during towing, the normally-on vacuum operated switch 25  
25   disconnects the vacuum pump. In this way, the vacuum pump is only in  
26   operation when vacuum is required.

1        [0022]    Means for contacting the brake pedal can be an integral part of  
2    the weight such as the corner or front end of a generally box-shaped weight.  
3    In addition, means for contacting the brake pedal can be a combination of a  
4    contact fixture for contacting the brake pedal and an attachment fixture for  
5    attaching the contact fixture to the weight. The attachment fixture can be a  
6    straight, bent or shaped bar, a plate, or a bracket held in place by a weld,  
7    a screw, a rivet, a magnet, a combination or plurality of any of the forgoing  
8    or any other rigid fastener or combination of rigid fasteners known in the  
9    art.   In addition, the attachment fixture can be a hinge or other fixture  
10   having at least one pivot axis with one side of the hinge attached to the  
11   weight and the other side of the hinge attached to the contact fixture in  
12   such a way as to permit a rocking motion around the pivot axis. Furthermore,  
13   the attachment fixture can include a plurality of hinges configured to permit  
14   a rocking motion about several pivot axes. The contact fixture can include a  
15   flat surface configured so that at least one geometrical tangent of the flat  
16   surface is substantially parallel to the face plate of the brake pedal during  
17   operation, a ribbed surface wherein the ribs are cut in a horizontal or  
18   vertical direction relative to the face plate of the brake pedal, a curved  
19   surface configured to permit a rocking motion when in contact with the brake  
20   pedal during operation or a roller configured to roll up and down the face  
21   plate of the brake pedal during operation. The curved surface and the roller  
22   can be essentially circular or have elliptical or nautilus type curvature.

23        [0023]    Sliding means between the base and the weight are configured to  
24    enforce a line of travel between the base and the weight and may include a  
25    stop to constrain the motion of the weight between a forward position and a  
26    rearward position and can include singularly or in combination, a lubricated,

1 generally concentric curved interface between the base and the weight, a  
2 lubricated tongue in groove assembly, a lubricated dove-tail assembly, a  
3 generally t-shaped slider in a slotted guide or the like. In addition,  
4 sliding means between the base and the weight can include a ball bearing  
5 guide assembly such as might be used as a drawer slide; examples of which are  
6 described by Hoffman in U.S. patent number 5,507,571, incorporated herein by  
7 reference, by Bayani in U.S. patent number 6,145,944, incorporated herein by  
8 reference, by Yang in U.S. patent number 6,386,660, incorporated herein by  
9 reference or the like. Further, sliding means between the base and the  
10 weight can include a wheel-type guide such as might be used in a drawer  
11 slide; examples of which are described by Fall in U.S. patent number  
12 4,200,342, incorporated herein by reference, by Houck in U.S. patent number  
13 5,580,174, incorporated herein by reference, by Grieser in U.S. patent number  
14 5,785,400, incorporated herein by reference or the like. Other sliding means  
15 between the base and the weight comprise an air bearing or magnetic  
16 levitation. The sliding means between the base and the weight can comprise a  
17 single slide assembly, a plurality of slide assemblies or can be used in  
18 combination.

19 [0024] Means for attaching the brake pedal to the weight include a  
20 magnet, an elastomer band, a swing hook assembly mounted at the top of the  
21 weight, a spring, a rope or the like.

22 [0025] Means for constraining the motion of the base include a magnet, a  
23 hooking mechanism for hooking into the carpet on the floor, a pair of rails  
24 mounted front-to-back on the bottom of the weight, a fastening mechanism such  
25 as a snap, velcro strips and hooks, loops and knobs, buttons and button holes  
26 using heavy cloth secured to the mount, a bungee cord secured between loops

1 or hooks on the base and a securable point on the towed vehicle, clamps  
2 secured to the towed vehicle or the like. The forgoing can be used singly or  
3 in combination wherein the combination employs the same or different means.

4 [0026] Means for moderating the motion of the weight can include  
5 lubrication of the slidable mount between the weight and the base wherein the  
6 lubrication material can be graphite, a light or stiff grease, light or  
7 viscous oil or the like. In addition, means for moderating the motion of the  
8 weight can include a spring, mounted between the weight and the towed vehicle  
9 or between the weight and the base, a bungee cord or other elastomer cord,  
10 mounted between the weight and the towed vehicle or between the weight and  
11 the base, a shock absorber or the like. The forgoing can be used singly or  
12 in combination wherein the combination employs the same or different means.

13 [0027] The base can be constructed of wood, metal ceramic, fiberglass  
14 composite, a combination of the forgoing or other suitable material.

15 [0028] The weight can be a solid object or can comprise a plurality of  
16 separable weight segments and can be constructed of various types of steel,  
17 iron, lead or other metal, ceramic, a metal polymer composite, a combination  
18 of any of the forgoing or other suitable material and should have sufficient  
19 mass to apply a braking force to the brake pedal of the towed vehicle during  
20 operation. In addition, various fixtures can be attached to the weight  
21 including a handle, a means for attaching the brake pedal to the weight,  
22 loops, hooks, hinges or the like for attaching certain means for moderating  
23 the motion of the weight and for securing the actuator during storage, or a  
24 combination of any of the forgoing. Inasmuch as such fixtures, alone or in  
25 combination, can contribute to the mass of the weight, such mass can be  
26 considered to be a part of the weight for the purpose of actuating the brake

1 pedal. Weights can range from about 25 to about 75 lb., with about 40 lb.  
2 being typical.

3 [0029] Springs, bungee cords or other elastomer materials used in this  
4 invention can have various Hook's law force constants in that the restoring  
5 force exerted is proportional to the distance of stretch. Typical linear  
6 force constants used in this invention are from about 0.5 to about 12 lb/in.  
7 In addition, spring devices can exhibit nonlinear behavior. For example,  
8 certain elastomers are distensible so that the restoring force changes with  
9 time for a given length of stretch. As another example, the restoring force  
10 can follow a quadratic or power law with the length of stretch. As another  
11 example, when a shock absorber and a spring, bungee cord or other elastomer  
12 are used in combination, the length of stretch will be responsive to a  
13 gradually applied force, such as when the combination is traversing a hill or  
14 when the brakes of the towing vehicle are applied gradually and less  
15 responsive to rapidly changing forces, such as when the combination  
16 encounters a pothole, a speed bump or other bump in the road. The  
17 sensitivity of such a combination can be optimized for various road  
18 conditions by selection of the proper components or adjusting the tension of  
19 the spring, bungee cord or elastomer material.

20 [0030] The auxiliary vacuum source can be an evacuated ballast tank, a  
21 connection to the vacuum system of the towing vehicle, an electrically  
22 operated vacuum pump such as that disclosed by Otto in U.S. patent number  
23 5,707,222, incorporated herein by reference or a vacuum pump such as might be  
24 available for use with electric or hybrid automobiles. The vacuum pump may  
25 include an integrated normally-on vacuum switch which eliminates the need for  
26 a separate vacuum switch. A commercially available vacuum pump suitable for

1 use with the present invention is the CEV vacuum pump kit, available from  
2 Canadian Electric Vehicles Ltd., Errington, BC V0R 1V0 Canada or the Thomas  
3 Vacuum pump, available from InnEVations of Santa Rosa, CA 95407. The former  
4 pump includes an integrated vacuum switch while the latter pump requires the  
5 use of a separate vacuum switch. The vacuum pump can be operated  
6 electrically or can be powered by the wheels while the towed vehicle is in  
7 motion. The auxiliary electric vacuum system typically has a manual on-off  
8 switch, a normally-on vacuum actuated switch, a vacuum pump, tubing and a  
9 check valve installed on the existing vacuum-assisted brake booster.

10 [0031] While the apparatus shown herein and disclosed in detail is fully  
11 capable of attaining the objects and advantages of this invention, it is to  
12 be understood that it is merely illustrative of the invention and that no  
13 limitations are intended to the details of construction or design other than  
14 as defined in the appended claims or their equivalents.

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